Geoscientific Model Development Discussions

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Comment on gmd-2021-399

Anonymous Referee #2

Referee comment on "An online ensemble coupled data assimilation capability for the Community Earth System Model: system design and evaluation" by Jingzhe Sun et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-399-RC2, 2022

This manuscript documented the development of an ensemble coupled data assimilation (ECDA) capability for the community earth system model (CESM). A traditional ocean data assimilation (ODA) was used in the CESM_ECDA, while the atmosphere data assimilation (ADA) part just assimilates surface pressure data. The CESM-ECDA was evaluated using one set of perfect data assimilation experiment and another set of real observation assimilation experiment.

The development of ECDA for CESM is an important work for CESM's climate prediction capability. One novelty of this work to only use surface pressure data in ECDA's ADA part. However, the implemented algorithm of the surface pressure data assimilation, which is different from the literature, needs further clarification and scientific justification. Therefore, I recommend "major revision" of this manuscript.

Specific comments:

1, For the surface pressure data assimilation, there are two important references updated recently. One is that the 20-CR has been updated to version 3 (20CRv3, Slivinski et al., 2019); Another is that a similar surface pressure data assimilation has been used in GFDL's SPEAR coupled model (Yang et al. 2021).

Slivinski, L. C., Compo, G. P., Whitaker, J. S., Sardeshmukh, P. D., Giese., B. S., McColl, C., et al. (2019) Towards a more reliable historical reanalysis: Improvements for version 3 of the Twentieth Century Reanalysis system. Q. J. R. Meteorol. Soc., 145, 2876-2908. https://doi.org/10.1002/qj.3598

Yang, X., T. L. Delworth, F. Zeng, L. Zhang, W. F. Cooke, M. J. Harrison, A. Rosati, S. Underwood, G. P. Compo, C. McColl, 2021: On the Development of GFDL's decadal prediction system: initialization approaches and retrospective forecast assessment, Journal of Advances in Modeling Earth Systems, 13, e2021MS002529

2, P6L175-180, In this study, the analysis increment is weighted and projected onto the pressure thickness at each model layer. This algorithm is different from 20-CR (Compo et al., 2011; Slivinski et al, 2019) and Yang et al. (2021), in which the analysis increments of winds, temperature and moisture are directed solved via the covariance with surface pressure. Without the simultaneous increments of winds, temperature and moisture, the dynamical balance between those fields and surface pressure would not be maintained. The authors need provide further justification for the choice of this algorithm.

3, P12L360, RMSE is a useful metric for assessing the data assimilation performance. One aspect of surface pressure data assimilation shown in 20CR is that 20CR could have very similar weather-to-climate scale variability in the troposphere as other traditional atmosphere reanalyses which use all available observations. Therefore, it is important to assess how well the weather variability in the middle troposphere (e.g., variability of the daily 500-mb geopotential heights) is retrieved by the surface pressure data assimilation.

4, P12L370, "U, V, T and Q are not used as direct assimilation variables, ….. The conclusion is consistent with previous studies such as 20-CR (Compo et al., 2011)." Further evidence is needed to support this conclusion, since the dynamical balance between U, V, T and Q and Ps is not maintained in the data assimilation step without the direct increments of U, V, T and Q. Some plots of representing weather variability in the upper troposphere (e.g., figure 7 and 9 in Compo et al, 2011) would be useful.

5, P13L385-390. The reduction rate of RMSEs for the variables in the upper layers is much smaller than that in the surface. This might suggest that the simultaneous increments of U, V, T and Q are very important for representing the atmosphere state in the whole troposphere.

6, P15L470-475, Are QF and LHF the same variable in physics just with different unit? Fig. 12d and f looks exactly the same.

7, P12L485, It is worth showing the global plot of the SST improving due to CDA.

8, P16L500-505. 20CRv3 should be used for this comparison.

9, P17L510. ERA-20C data is an atmosphere reanalysis product. I don't see any scientific

merit of comparing SST from ERA-20C, since the SST should be observed HADISST. The SST RMSE reduction compared with ERA-20C is simply due to the difference between different SST observations.